

FIG. 1

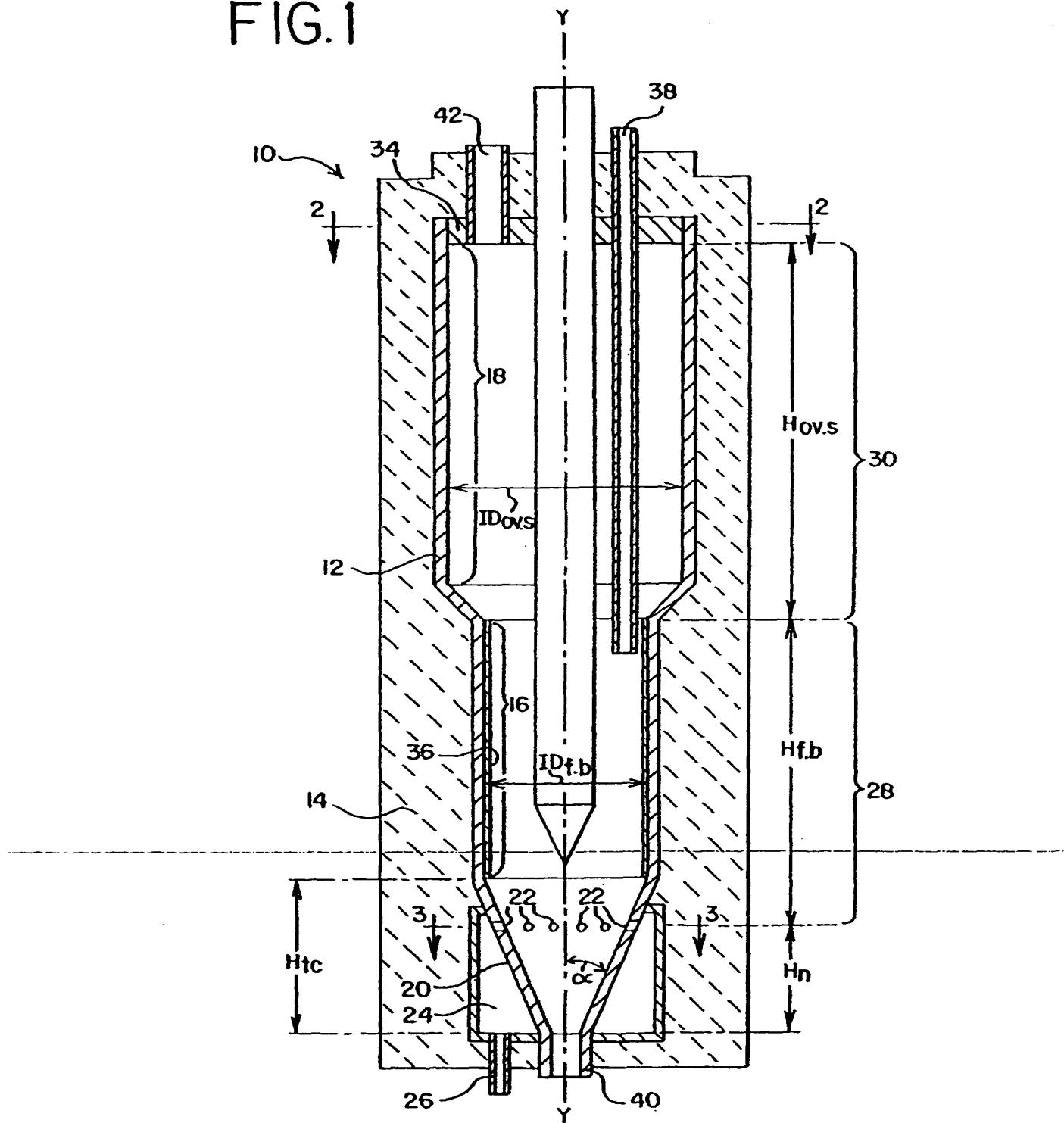


FIG. 2

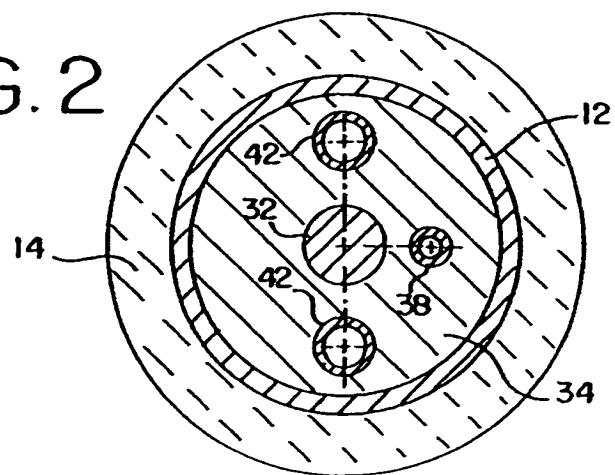


FIG. 3

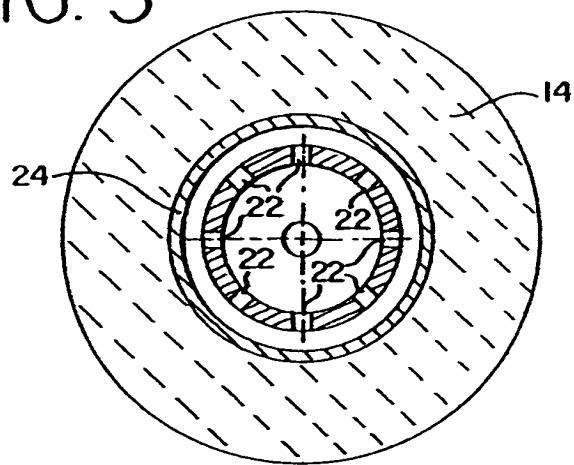
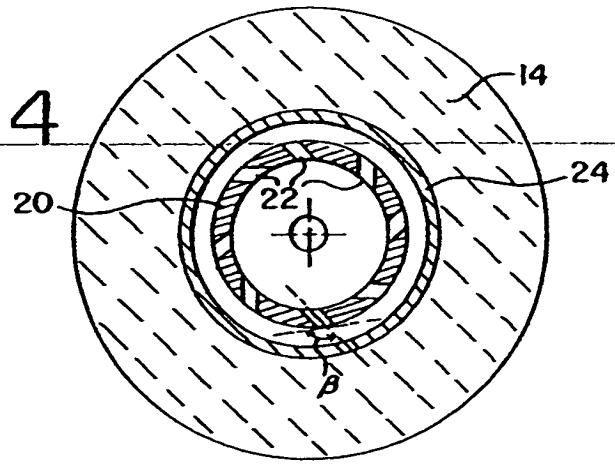


FIG. 4



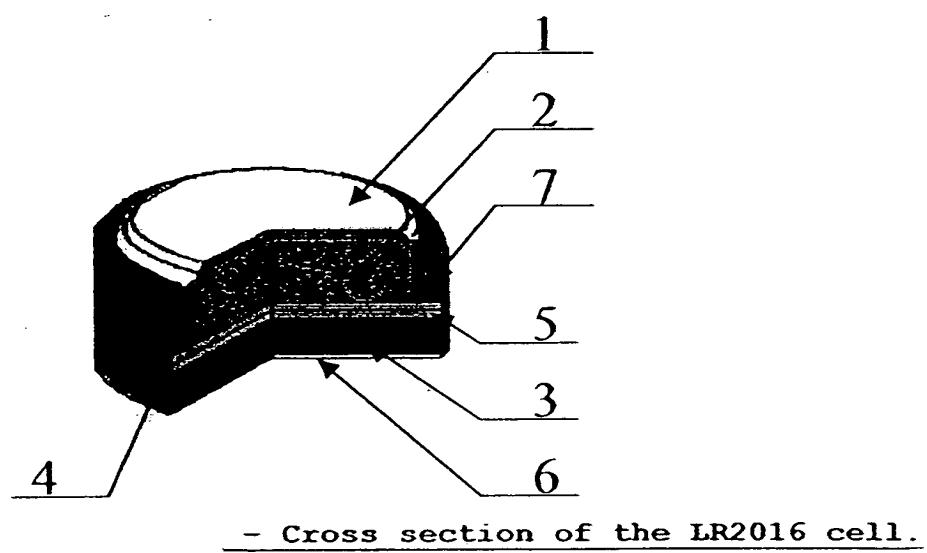


FIG. 5

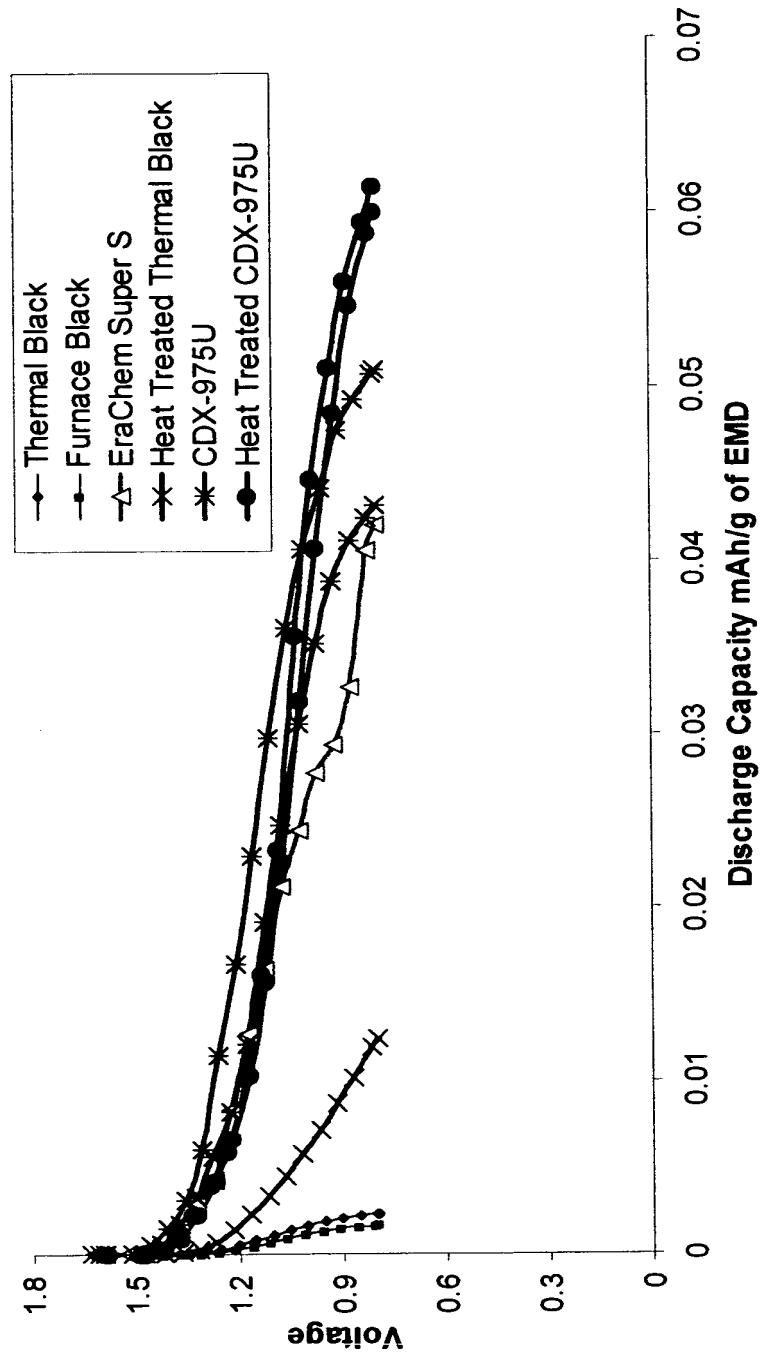


Fig. 5A

Table 1: Matrix of Carbon Black Properties Imparted as a Result of Thermal Modification and Their Effect on Various Applications

Property	Wire & Cable	Food Contact	Moisture Cured Systems	Battery		Other Energy Systems
				Dry Cell	Alkaline	
Moisture Pickup (MPU) Reduction	+ve		+ve			
Poly Aromatic Hydrocarbons (PAH) Reduction		+ve				
Oxidation Resistance	+ve			+ve	+ve	+ve
Increased Graphitic Order	Electrical Conductivity/Volume Resistivity	+ve		+ve	+ve	+ve
	Thermal Conductivity					+ve
Sulfur Reduction	+ve			+ve	+ve	+ve
Reduced Volatile Metals	+ve		+ve	+ve	+ve	+ve
Improved Melt Flow	+ve		+ve			
Resiliency				+ve		
Electrolyte Absorption				+ve	+ve	+ve

TABLE 2: Moisture pick-up data for As-is and Heat-Treated Carbon Blacks

Sample	1 hr moisture pick-up (%)	Equilibrium moisture pick-up (%)
Medium Thermal Black	0.18	0.31
Heat-Treated Medium Thermal Black	0.02	0.04
CDX-975U	2.41	3.38
Heat-Treated CDX-975U	0.17	0.27
N220	1.48	2.72
Heat-Treated N220	0.08	0.24
N330	0.60	1.98
Heat-Treated N330	0.02	0.13

Table 3: Metal Impurities, Ash and Sulfur Content of As-Is and Heat-Treated Carbon Blacks

	N220	HT N220	N330	HT N330
Ash (%)	0.48	0.09	0.30	0.06
Al (ppm)	20	9	48	55
Fe (ppm)	65	15	72	33
K (ppm)	162	26	52	21
Si (ppm)	21	2	87	2
Na (ppm)	695	31	607	65
S (%)	1.02	0.10	1.23	0.13

Table 4: Colloidal Properties

	CDX-975U	Heat-Treated CDX-975U	Acetylene Black
Iodine (mg/g) ASTM D1510	250.9	90.8	86.3
NSA (m ² /g) ASTM D4820	227	71.9	73.1
DBPA (ml/100g) ASTM D2414	173	165	207
Sulfur (%) ASTM D1619	0.45	0.01	0.01
pH ASTM D1512	6.5	10.6	9.2
Moisture	0.7	0.0	0.0

Table 5: Structure Stability of Very High Structure (VHS) Blacks

Property	Method	Unit	Acetylene Black	Heat-Treated CDX-975U	CDX-975U
Oil Absorption Number	ASTM D2414	ml/100g	189.1	159.1	177.9
COAN	ASTM D3493				
1 st Compression		ml/100g	152.5	151.8	157
2 nd Compression		ml/100g	132.8	142.7	144.6
3 rd Compression		ml/100g	123.2	136.3	137
4 th Compression		ml/100g	114.5	130.3	130.3

Table 6: Moisture pick-up (MPU) and Melt Flow Properties @ 30% Loading in 10MI LDPE

	CDX-975U	Heat-Treated CDX-975U	Acetylene Black
MPU 1-hour Carbon Black(%)	1.75	0.17	0.15
MPU Equilibrium Carbon Black (%)	3.02	0.27	0.31
MPU Equilibrium Masterbatch	0.1	0.01	0.03
Melt Flow Index (g/10 min)	6.6	7.0	6.8

Table 7: Volume Resistivity Versus Processability in Polyethylene

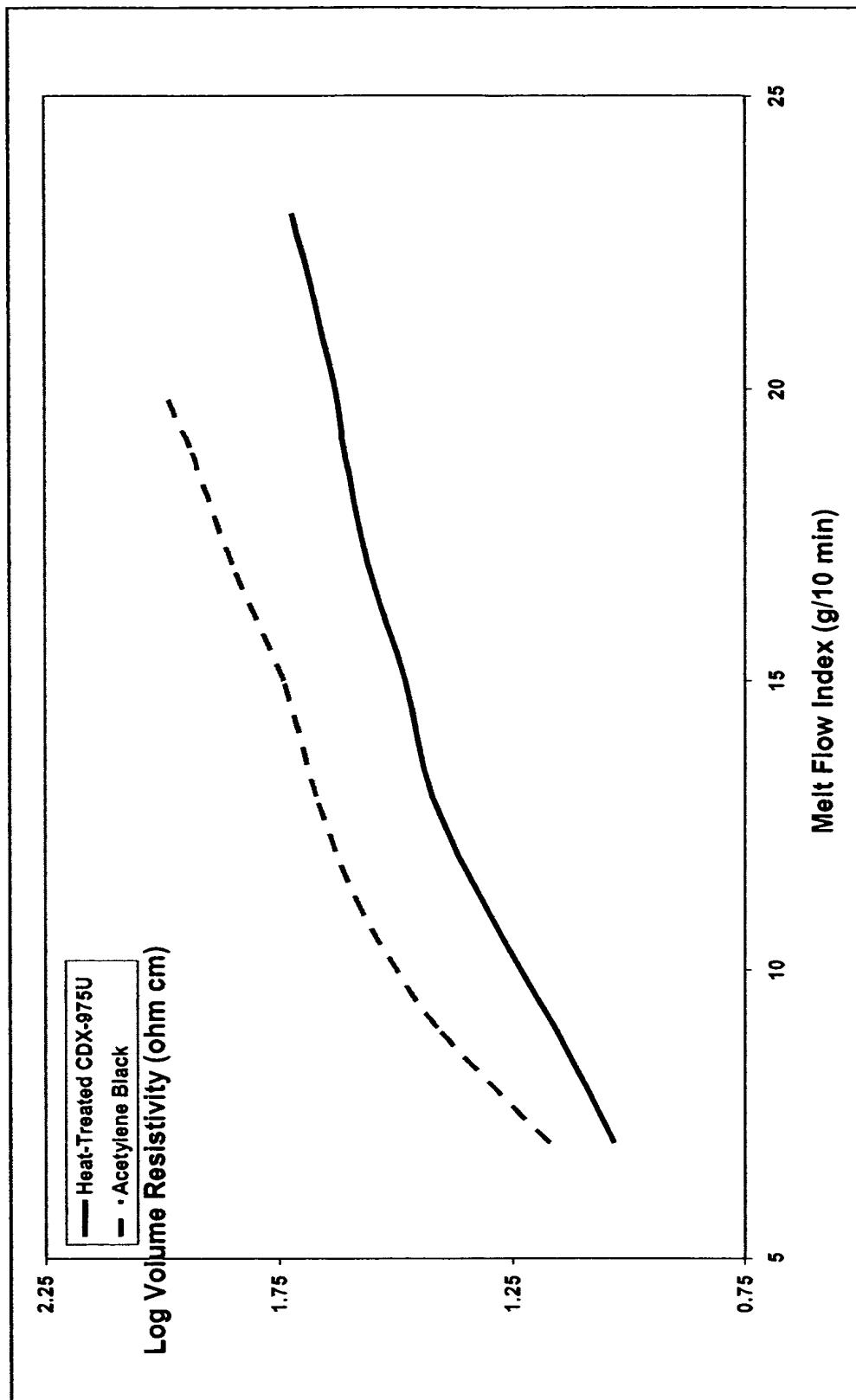


Table 8: Combustion rate and Activation Energy of CDX-975U – Before and After Heat-Treatment

Temperature, °C	Heat-Treated CDX-975U		CDX975U	
	In Air (%/min)	In Oxygen	In Air (%/min)	In Oxygen
450	0.000008	0.00008	0.00654	0.03237
500	0.00034	0.0016	0.05988	0.2201
550	0.00213	0.01950	0.3198	1.245
600	0.05144	0.32100	1.260	17.81
650	0.36530	1.5670	3.466	28.24
	Activation Energy (kcal/ mole)		Activation Energy (kcal/ mole)	
	73.2	70.7	40.8	43.8

Table 9: PAH Compounds Regulated by FDA

Group	PAH Compounds	Molecular Weight	Boiling Point (°C)
1	Naphthalene	128.2	218
2	Acenaphthylene	152.2	280
	Acenaphthene	154.2	279
3	Fluorene	166.2	295
4	Phenanthrene	178.2	342
	Anthracene	178.2	342
5	Fluoranthene	202.3	393
	Pyrene	202.3	393
6	Benzo(g,h,I) fluoranthene	226.3	
	Benz(a) anthracene	228.3	400
	Cyclo penta (c,d) pyrene	226	
	Chrysene	228.3	448
7	Benzo (b) fluoranthene	252.3	481
	Benzo (k) fluoranthene	252.3	480
	Benzo (e) pyrene	252.3	493
	Benzo (a) pyrene	252.3	496
	Perylene	252.3	497
8	Indeno (1,2,3,cd) pyrene	276.3	536
	Dibenz (a,h) anthracene	278.4	524

	1, 12 benz perylene	276.3	542
	Anthanthrene	276.3	525
9	Coronene	300.4	525

Table 10: PAH Content (ppb) of FDA Compliant Competitive Carbon Black, Heat-Treated CDX-975, Heat-Treated N700 Series Carbon Black and Control N700 Series Carbon Black

	FDA Compliant Competitive Carbon Black	Heat Treated CDX-975U Carbon Black	Heat Treated N700 Series Carbon Black	N700 Series Carbon Black
Naphthalene	137	12	43	2,761
Acenaphthylene	<1	<1	8	3,499
Acenaphthene	1	<1	2	5
Fluorene	<1	<1	<1	62
Phenanthrene	7	4	6	6,065
Anthracene	1	1	2	649
Fluoranthene	8	2	14	12,251
Pyrene	40	3	50	71,282
Cyclopenta pyrene	<1	<1	<1	901
Benzo (ghi) fluoranthene	<1	<1	<1	<1
Benz (a) anthracene	<1	<1	<1	705
Chrysene	4	<1	<1	235
Benzo(b) fluoranthene	<1	<1	<1	990
Benzo (k) fluoranthene	<1	<1	<1	<1
Benzo (e) pyrene	<1	<1	2	3,912
Benzo (a) pyrene	<1	2	2	4,878
Perylene	7	<1	8	830
Indeno (1,2,3,cd) pyrene	<1	<1	3	5,585
Di benz(a,h) anthracene	7	<1	5	<1
1,12 Benz perylene	<1	<1	<1	<1
Anthanthrene	<1	<1	<1	827
Coronene	70	21	60	69,304
Total PAH, ppb	280	44	205	184,741

Table 11: PAH (ppb) content of As-Is N220, N330, Heat-Treated N220 and Heat-Treated N330

	N220	N330	Heat-Treated N220	Heat-Treated N330
Naphthalene	201	189	153	24
Acenaphthylene	614	764	24	<1
Acenaphthene	<1	<1	8.6	<1
Fluorene	<1	<1	1.5	1.8
Phenanthrene	3099	476	15	5.1
Anthracene	<1	400	17.8	<1
Fluoranthene	870	1559	20	4.9
Pyrene	1744	16490	85	32
Cycloperita pyrene	<1	286	<1	2.6
Benzo(ghi) fluoranthene	<1	<1	<1	<1
Benz(a) anthracene	<1	<1	1.1	<1
Chrysene	4075	<1	<1	<1
Benzo(b) fluoranthene	<1	<1	<1	<1
Benzo(k) fluoranthene	<1	106	<1	<1
Benzo(e) pyrene	<1	223	7.7	<1
Benzo(a) pyrene	<1	94	<1	<1
Perylene	<1	<1	<1	<1
Indeno(1,2,3,cd) pyrene	<1	190	<1	<1
Di-berz(a,h) anthracene	13306	<1	<1	<1
1,12 Benz perylene	3963	3422	<1	<1
Anthanthrene	<1	<1	<1	<1
Coronene	7426	10516	1.1	<1
Total PAH, ppb	35310	34723	344.8	85.4

Table 12: Summary of Maximum Discharge Capacity of as is and Heat-treated Carbon Black Samples at Three Discharge Rates

Sample	Cathode Mixture	Cathode Capacity mAh		
		Discharge Current 100 mA	Discharge Current 50 mA	Discharge Current 25 mA
Commercial Sample	Unknown	745	905	919
Carbon Black A (NSA 77 m ² ·g ⁻¹) (OAN 174 ml/100 g)	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	340	600	
Carbon Black B (NSA 173 m ² ·g ⁻¹) (OAN 192 ml/100 g)	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	486	840	997
Carbon Black C (NSA 62 m ² ·g ⁻¹) (OAN 185 ml/100 g)	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	535	786	919
A-20961 Acetylene Black	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	679	812	979
HT Carbon Black B (NSA 109 m ² ·g ⁻¹) (OAN 199 ml/100 g)	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	641	886	939
HT Carbon Black A (NSA 72 m ² ·g ⁻¹) (OAN 182 ml/100 g)	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	626	750	901
HT Carbon Black C (NSA 54 m ² ·g ⁻¹) (OAN 171 ml/100 g)	MnO ₂ : 87.5% Carbon Black : 10.5% Graphite : 2%	636	780	915